Underfloor Air: Better Models, Better Performance

The Problem

Underfloor air distribution (UFAD) systems, in which raised access floors serve as plenums for distributing cooled air through buildings, offer the potential to reduce energy use under certain conditions (**Figure 1**). However, computer modeling techniques have not yet been accurate enough for designers to consistently make the right choices when considering the application of UFAD.

The Solution

Researchers have developed a new module for the U.S. Department of Energy's EnergyPlus™ software that is capable of modeling UFAD systems. EnergyPlus™ is a whole-building simulation software tool. The new EnergyPlus™/UFAD model can be used by designers to calculate the energy use of UFAD systems and compare their performance to conventional overhead air distribution systems. Using data from a multiyear study, the software allows designers to better understand how UFAD systems work. That improved understanding will lead to better system design and increased efficiency.

Features and Benefits

Three factors improve the accuracy of UFAD modeling in the EnergyPlus™/UFAD software:

Improved representation of room air stratification (RAS). A two-zone RAS model, which was developed and validated based on a number of laboratory tests, allows EnergyPlus™/UFAD to divide a room into two temperature zones: a lower occupied zone and an upper zone (**Figure 2**). The EnergyPlus™ software determines the height of separation between the two zones and then analyzes how the temperatures in each zone interact with one another. In addition, the software models how heat sources such as computers and diffusers affect the UFAD system's performance.

Figure 1: UFAD in action

In an underfloor air distribution (UFAD) system, conditioned air is distributed from the underfloor plenum into the occupied room. As the cool air becomes warmer, it rises and exits the room through the return-air plenum at ceiling level.

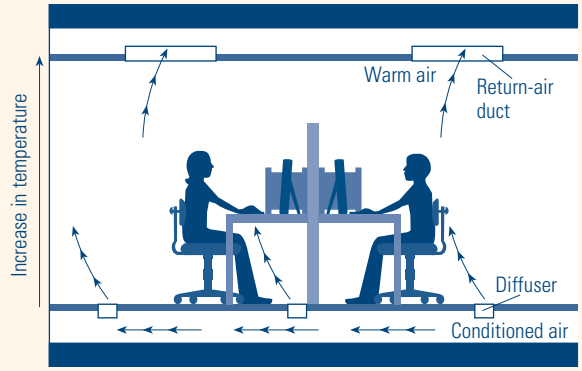
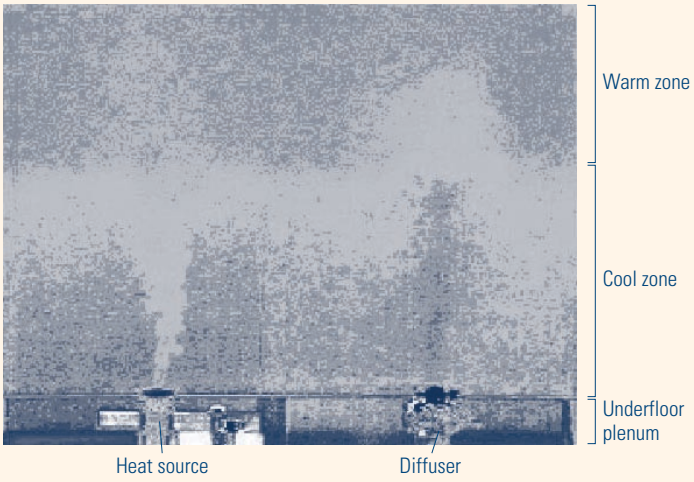


Figure 2: Visualizing room air stratification

To develop a model of room air stratification, researchers conducted tests using different numbers of diffusers and heat sources. In this false-color image, you can see the plume from the heat source (at left) rising to meet the stratified upper zone of warm air and the cool air from the diffuser (at right) remaining in the lower zone of the room.



Detailed plenum modeling. Because the underfloor air plenum is cooler than both the slab underneath it and the raised floor panel, heat transferring into the plenum becomes an important issue when modeling energy balances. To develop an accurate underfloor plenum model, researchers conducted tests on plenums of various shapes, sizes, and materials (**Figure 3**, next page). As a result, the EnergyPlus™/UFAD software can estimate the magnitude of heat infiltrating into the plenum from above and below.

Additional HVAC modules. Researchers also developed a way to model two HVAC elements commonly used with UFAD systems: a variable-speed fan coil unit and a return-air bypass arrangement. Variable-speed fan coil units are used for supplying air to the perimeter zones of the UFAD systems. Return-air bypass arrangements are commonly used to provide humidity control for systems in humid climates.

Figure 3: Modeling the performance of underfloor plenums

Full-scale tests were performed in the Center for the Built Environment at the University of California, Berkley test facilities to determine how shape, size, and materials affected the thermal performance of underfloor air supply plenums. Based on these results, models were developed and implemented in the EnergyPlus software.

Applications

EnergyPlus™/UFAD is a whole-building simulation program that can be used by design professionals or others to model any building, whether it is new construction or retrofit. Buildings located in all climates can be simulated because the EnergyPlus™ database continuously collects weather data from around the world.

California Codes and Standards

UFAD will be eligible as a compliance option in the 2008 Title 24 Building Energy-Efficiency Standards to be implemented beginning in 2009.

What's Next

In addition to improving the EnergyPlus™/UFAD software, the Center for the Built Environment is also developing a UFAD cooling airflow design tool that is separate from EnergyPlus™/UFAD. As a subtask of the UFAD study, the spreadsheet-based design tool estimates the amount of air needed to handle a cooling load in a UFAD system. The preliminary version of the design tool is complete, but additional research will be conducted this year to improve it. The design tool, in its current form, will be available soon on the California Energy Commission's Public Interest Energy Research (PIER) web site.

This project and other recent work have shown that UFAD systems have fundamentally different heat transfer pathways than conventional overhead systems. As a result, ASHRAE Technical Committee 4.1 is planning a detailed UFAD load-calculation project to develop a robust set of tools for UFAD designers.

Collaborators

The organizations involved in this project include the Center for the Built Environment, the University of California at San Diego, Lawrence Berkeley National Laboratory, and York International. Most of the funding for the model development came from the PIER Buildings program, with the other organizations providing additional funding as well.

For More Information

Reports documenting this project and providing more details may be downloaded at www.energy.ca.gov/2007publications/CEC-500-2007-050/CEC-500-2007-050.PDF.
The EnergyPlus™/UFAD program is available at www.energyplus.gov/

More PIER Technical Briefs can be found at www.energy.ca.gov/research/techbriefs.html.

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About PIER

This project was conducted by the California Energy Commission's Public Interest Energy Research (PIER) Program. PIER supports public interest energy research and development that helps improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

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